WASI-2D: A free software for inverse modelling of multi- and hyperspectral water images

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Introduction

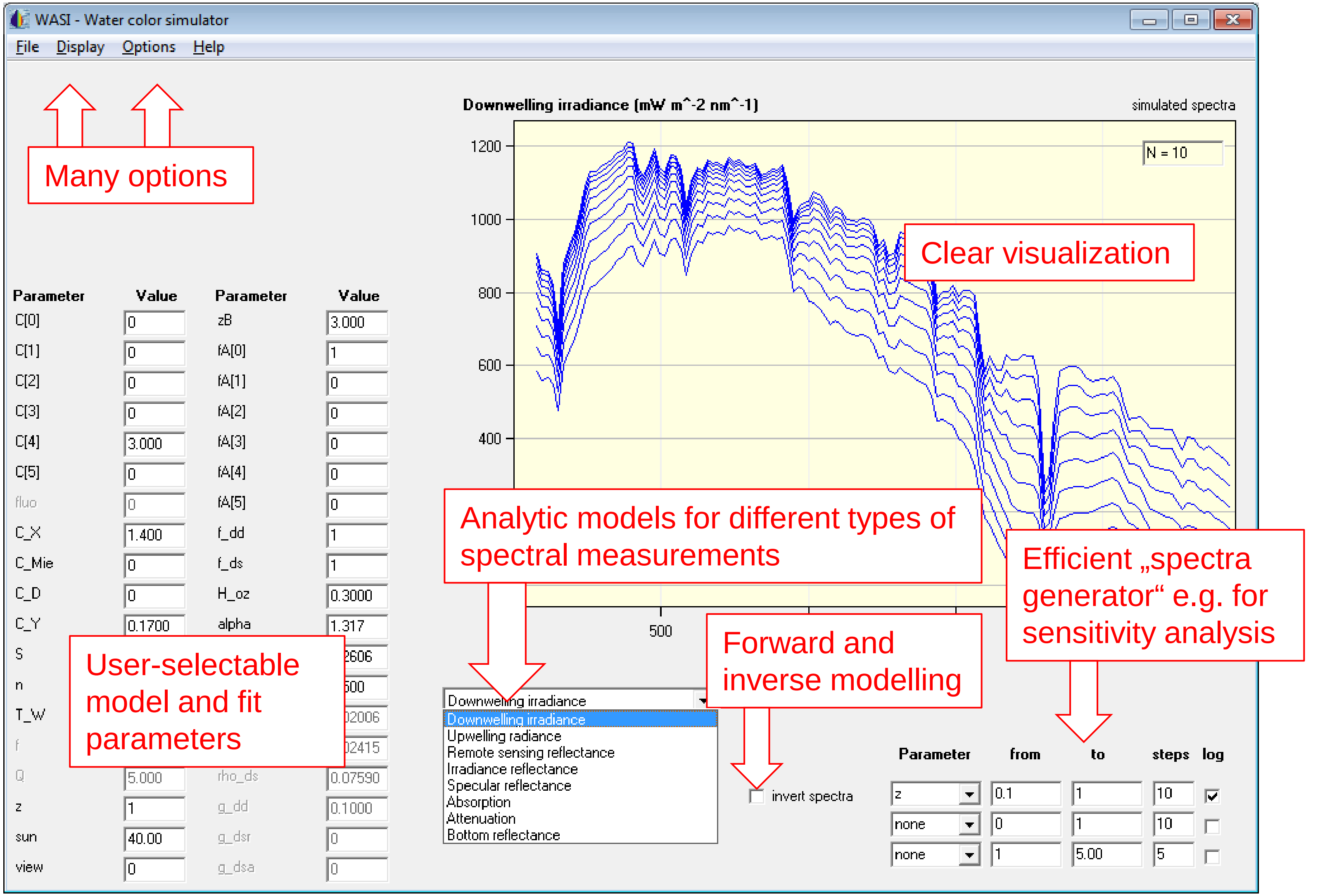
Motivation: Lack of freely available software for

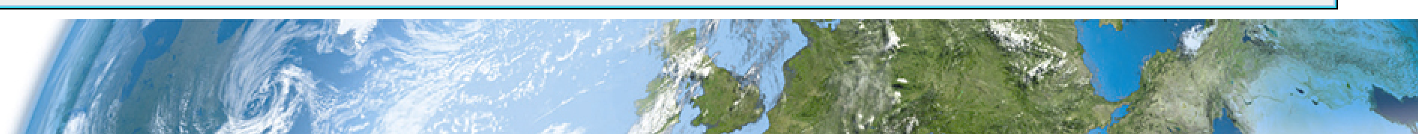
- All types of water (oceanic, coastal, inland, shallow)
  - ➢ Site specific adaptation of model parameters incl. optical properties
  - ➢ Physical approach (analytic models)
- All calibrated sensors (airborne and satellite; multi- and hyperspectral)
  - ➢ Sensor specific adaptation

Goal: Wide range of applications

- Software easy to use
  - ➢ GUI, stand-alone, user manual
- Models consistent to in-situ models (Cal/Val)
  - ➢ WASI-2D implemented as module into Water Color Simulator WASI

The Water Color Simulator WASI: GUI





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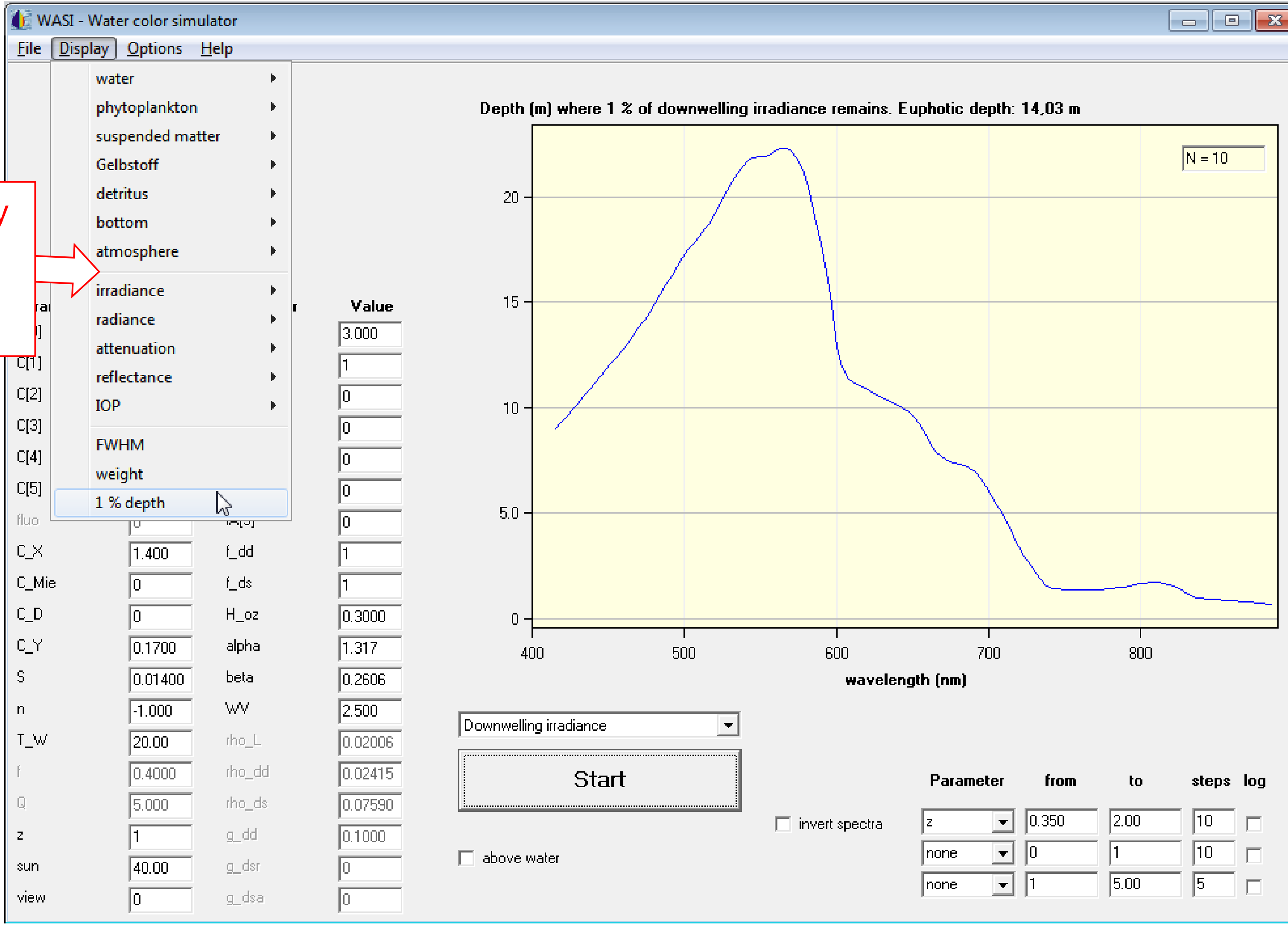
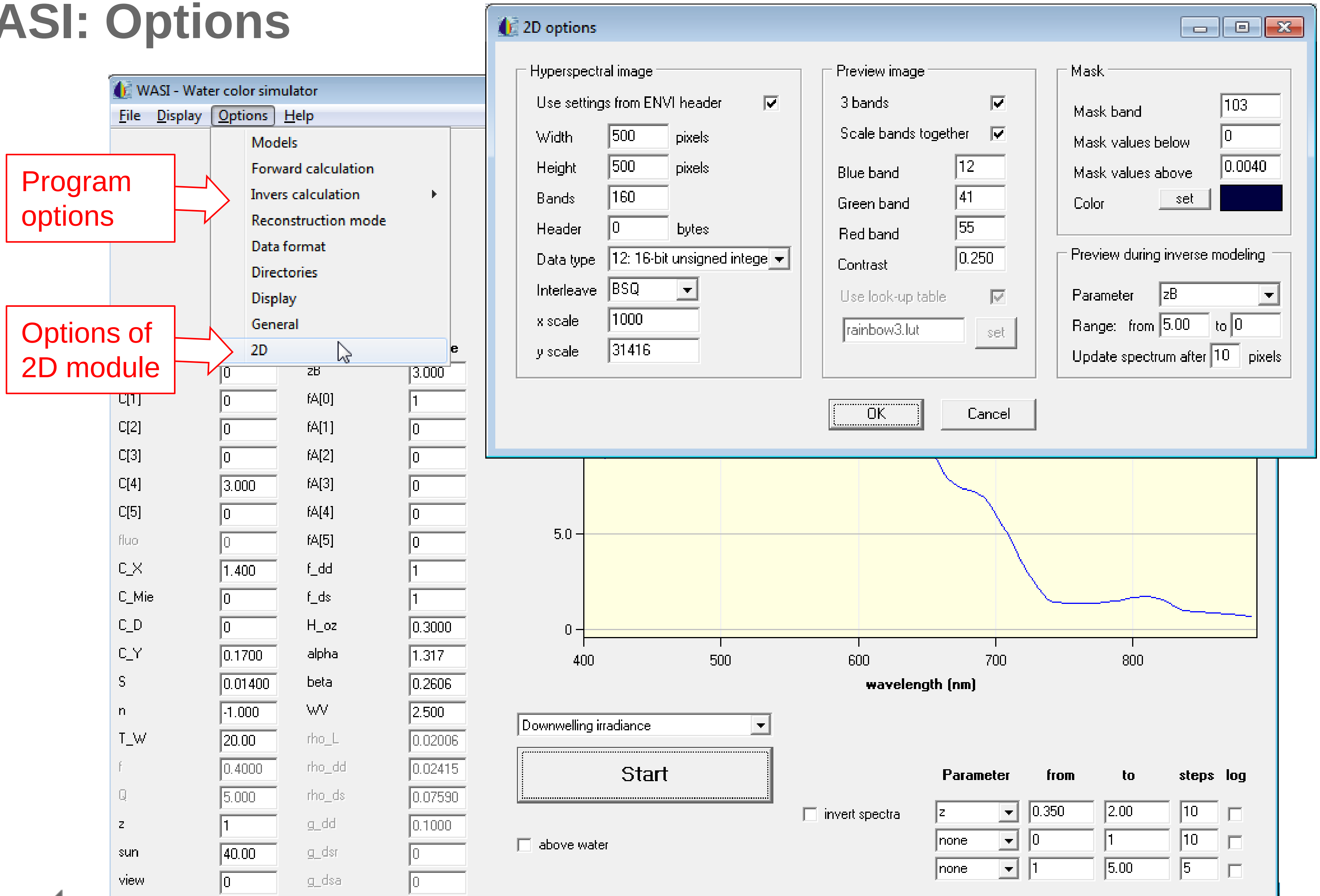
WASI: Options

Display internally used spectra and spectra of interest



WASI: Options



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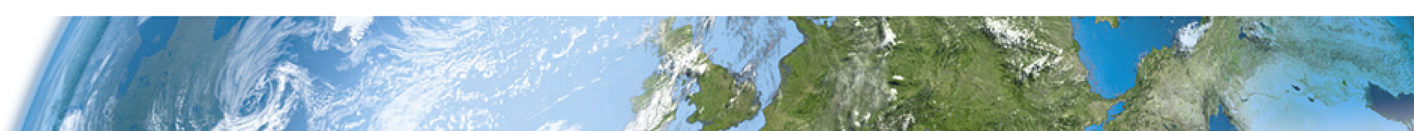
Models

- Reflectance: Albert[1,2]
  - Deep and shallow waters
  - Empirical coefficients adjusted using Hydrolight
  - Similar to model of Lee[3,4]
- Downwelling irradiance: Gregg and Carder[5]
  - For conversion reflectance $\leftrightarrow$ radiance
  - For calculation of sunglint and skyglint

1. Albert, A., Mobley, C.D. (2003). An analytical model for subsurface irradiance and remote sensing reflectance in deep and shallow case-2 waters. *Optics Express, 11,* 2873-2890.
2. Albert, A. (2004). Inversion technique for optical remote sensing in shallow water. Ph.D. Dissertation, Universität Hamburg, Germany, 188pp.
3. Lee, Z.P., Carder, K.L., Mobley, C.D., Steward, R.G., Patch, J.S. (1998). Hyperspectral remote sensing for shallow waters: 1. A semianalytical model. *Applied Optics, 37,* 6329–6338.
4. Lee, Z.P., Carder, K.L., Mobley, C.D., Steward, R.G., Patch, J.S. (1999). Hyperspectral remote sensing for shallow waters: 2. Deriving bottom depths and water properties by optimization. *Applied Optics, 38,* 3831-3843.
5. Gregg, W.W., Carder, K.L. (1990). A simple spectral solar irradiance model for cloudless maritime atmospheres. *Limnology and Oceanography, 35,* 1657–1675.



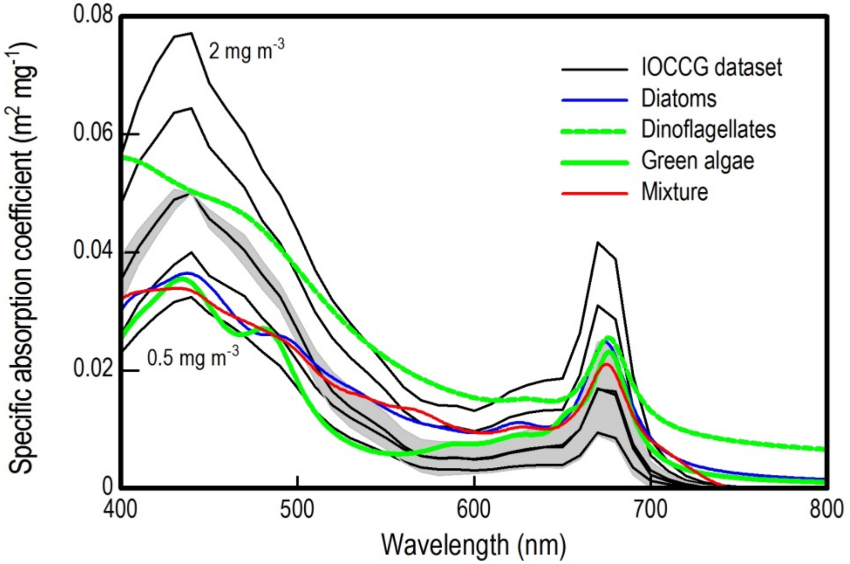
Optical properties

- Phytoplankton: mixtures of 1 – 6 types
  - Specific absorption $a_i^*(\lambda)$ imported from ASCII files
- Suspended matter: mixtures of 1 – 2 types
  - Type 1: Scattering with arbitrary λ–dependency; $b_X(\lambda)$ imported from ASCII file
  - Type 2: Scattering proportional to $(\lambda/\lambda_S)^n$ (Mie scattering)
- Coloured dissolved organic matter (CDOM, Gelbstoff)
  - Specific absorption $a_Y^*(\lambda) = \exp[-S(\lambda-\lambda_0)]$; or
  - Specific absorption $a_Y^*(\lambda)$ imported from ASCII file
- Detritus
  - Specific absorption $a_D^*(\lambda)$ imported from ASCII file

Adaptation

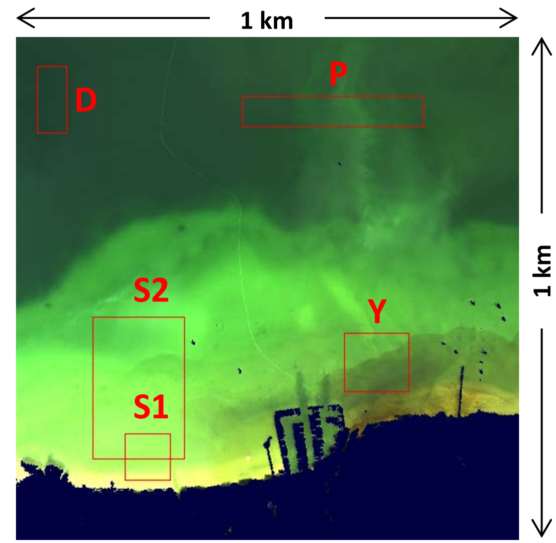
- Model applicable in all aquatic environments (open oceans, coastal waters, lakes …)
- Data base of inherent optical properties (IOPs)
  - Defaults from Lake Constance (Bodensee) lie well within range of other water types
  - Use site-specific IOPs whenever possible
    - Rank 1: Absorption of CDOM and phytoplankton
    - Rank 2: Scattering
- Sensor properties
  - Center wavelengths
  - Bandwidths (FWHM)

Phytoplankton absorption

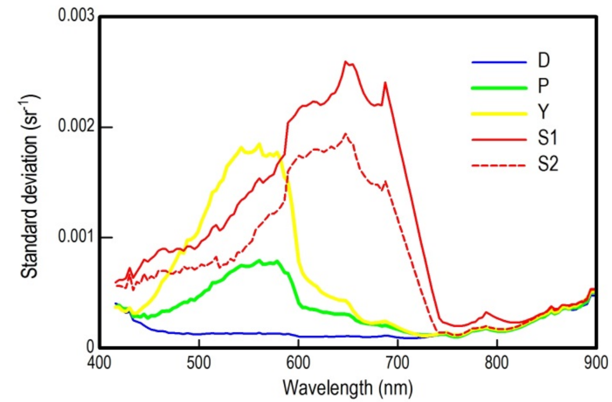


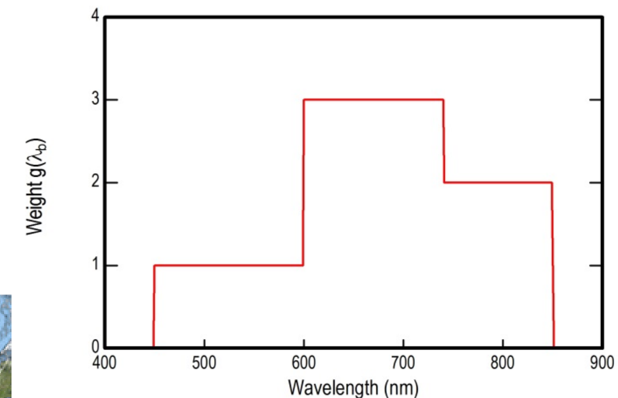
Preparation of data analysis

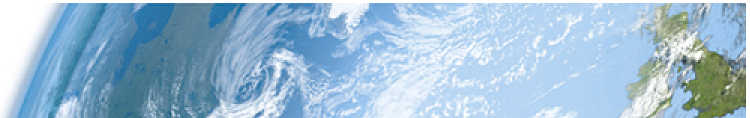
- Preprocessing
  - Calibration
  - Atmosphere correction
  - Georeferencing
- Adaptation of optical properties
  - SIOPs of water constituents
  - Bottom reflectance
- Preparation of inversion
  - Specify and initialize fit parameters
  - Adjust spectral range and weighting
  - Set thresholds for residuum and no. of iterations



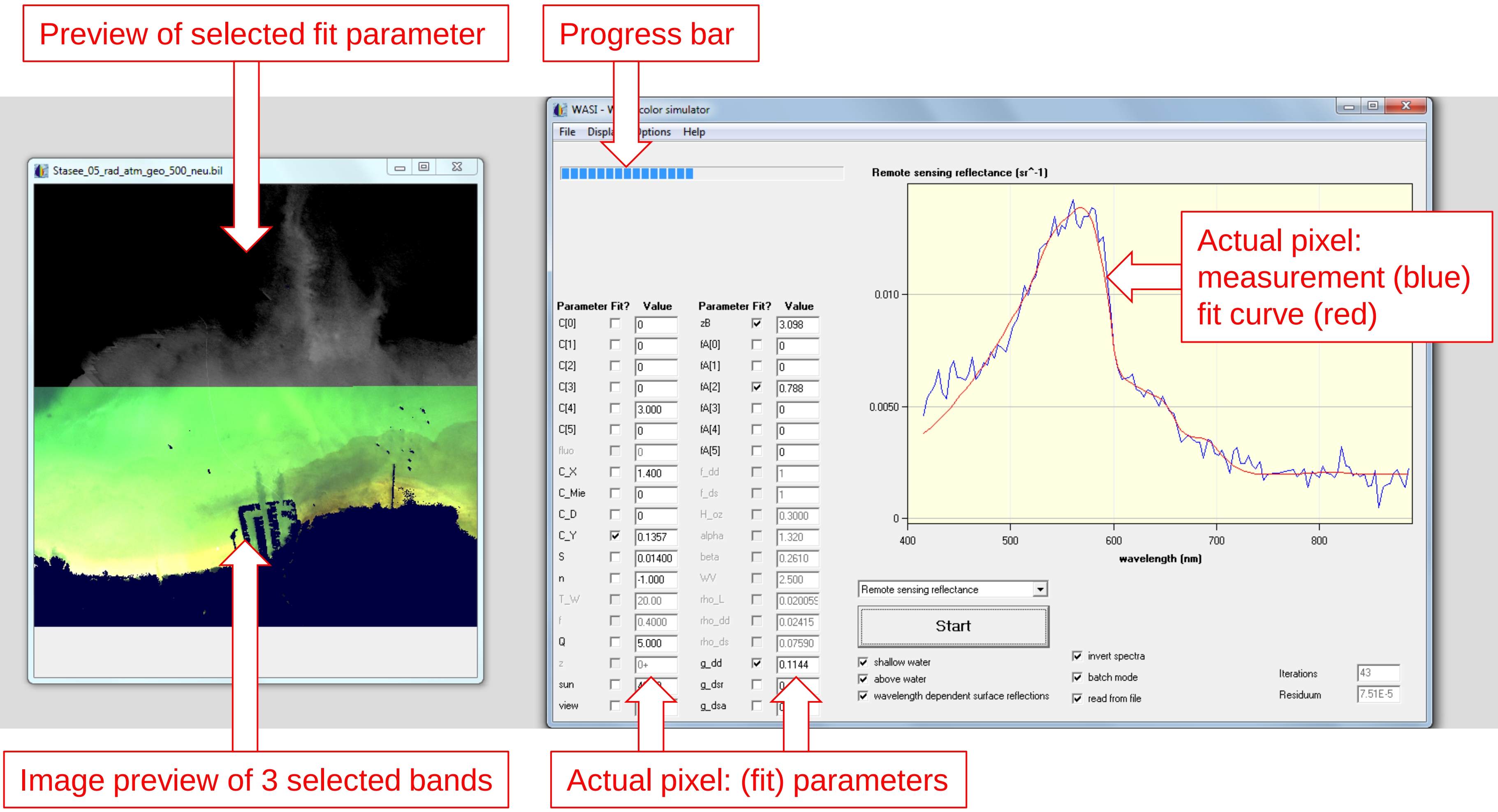
HySpex image
from Starnberger See





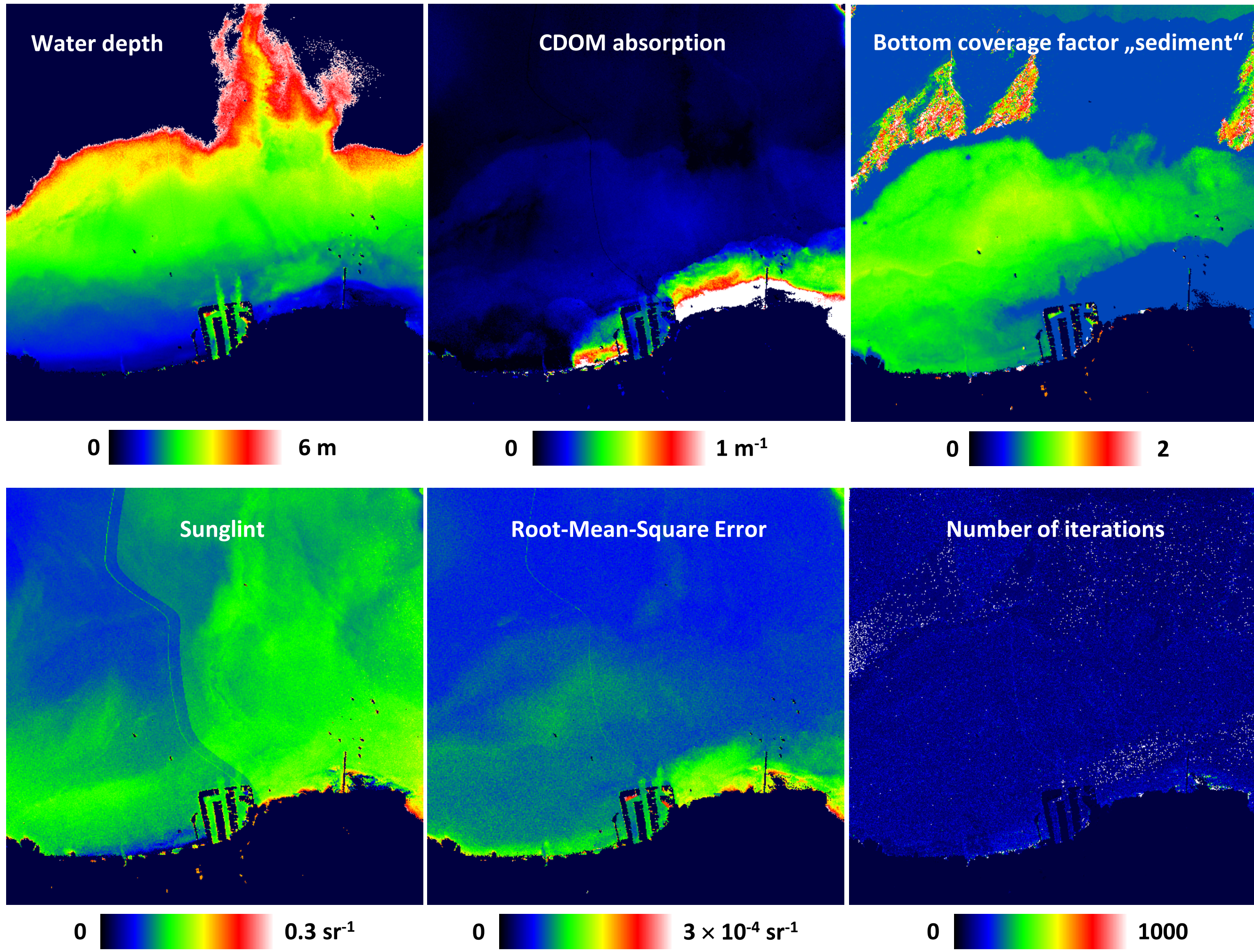


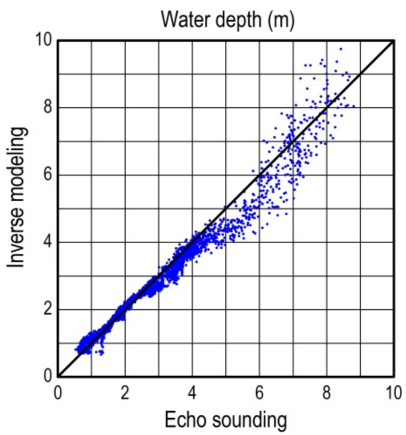
Data processing



Validation

- Check plausibility of parameter images
- Validate fit parameters





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Summary and Conclusions

- Inverse modelling of atmospherically corrected image data
  - Airborne sensors, satellite instruments
  - Multi- and hyperspectral data
  - Deep and shallow waters
- Regionally optimized data analysis
  - Regional / seasonal adaptation of optical properties
  - Not designed for automated processing of large datasets
  - Requires experienced users
- Intendend for research and education, not for commercial applications

Executable software is on IOCCG page: www.ioccg.org/data/software.html

Sourcecode (Borland Delphi) is available on request: peter.gege@dlr.de